DOCUMENT RESUME

ED 082 511 EM 011 484

AUTHOR	Hofstetter, Fred T.
TITLE	Computer Applications to Music at the Ohio State University: Summer, 1971 through Winter, 1973.
INSTITUTION	Ohio State Univ., Columbus. School of Music.
PUB DATE	22 Jul 73
NOTE	12p.; Paper presented at the International Conference on Computers in the Humanities (Minneapolis, Minnesota, July 22, 1973)
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	College Students; *Computer Assisted Instruction; *Computer Oriented Programs; *Computer Programs; Computers; Higher Education; Music Activities; *Music Education; Music Facilities; Music Theory; Program Descriptions
IDENTIFIERS	Ohio State University

ABSTRACT

An analytic, statistical, synthetic, bibliographic, instructional, and automated music printing systems is currently available at the Ohio State University. The computer analysis of music is described here, and a list of programs available for computer-assisted musical analysis is presented. Statistical research in music education is considered next, and then four computer programs comprising the computer sound synthesis system are discussed. The development of a general purpose bibliographic system is briefly described, and some aspects of computer-assisted instruction in music theory are considered. Brief sections on automated music printing and the future conclude the paper. (Author/SH)

FILMED FROM BEST AVAILABLE COPY

ED 082511

Computer Applications to Music at The Ohio State University: Summer, 1971 through Winter, 1973

by

Fred T. Hofstetter

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

Presented at the Computer Science Conference,
Neil House, Columbus, Ohio,
February 21, 1973

Distributed at the International Conference on Computers in the Humanities,
University of Minnesota,
July 22, 1973,
In connection with a presentation of computer-assisted style analysis at OSU

EM 011 484

It will be the purpose of this paper to describe and illustrate analytic, statistical, synthetic, bibliographic, instructional, and automated music-printing systems currently available at The Ohio State University, and to identify scholars active in each area.

TABLE OF CONTENTS

I. Analytic Systems 1

II. Statistical Research in Music Education 3

III. Synthetic Systems 4

IV. Bibliographic Systems 6

V. Computer-Assisted Instruction in Music Theory 6

VI. Automated Music-Printing 7

VII. The Future 8

Bibliography 9

Acknowledgements 10

I. Analytic Systems

The first requirement for computer analysis of music is a coding language whereby musical notation can be translated into a machine-readable form. Ohio State researchers have adopted MUSICODE (Hofstetter, 1972a), an extended version of the language proposed for international adoption by Barry S. Brook (1964). Four versions of MUSICODE have been developed, ranging from a complete version which codes every aspect of a conventional score to an abridged version which includes pitch-class and durational codes only. These versions are upwards compatible, i.e., programs designed to operate on abridged versions will also operate on complete versions.

A syntax verifier program is available which reveals syntactical and logical errors in MUSICODE representations. Mrs. Ann Blombach, graduate teaching associate in music theory at Ohio State, is writing a program which translates DARMS, a code devised by Stefan Bauer-Mengelberg, into MUSICODE and vice versa. This program will permit universities using DARMS to trade coded compositions with Ohio State, avoiding needless duplication of effort.

Programs available for computer-assisted musical analysis are as follows:

1) ROW-TEASE:- finds and identifies twelve-tone rows, indicating permutational relationships among them. Author - Fred Hofstetter.

2) INFORMATION THEORY ANALYSIS:- computes the amount of information in each phrase, as developed by Hiller and Bean (1966). Author - Daniel Harris.

3) ZERO-ORDER STATISTICS:- produces frequency counts of each pitch-class used in the composition. This information is classified according to number of attacks, total duration, and octave placement. Author - Fred Hofstetter.

4) FIRST-ORDER INTERVALS:- produces frequency counts and percentages of occurrence of intervals expressed by the number of half-steps in the intervals, quantitative numerals, qualitative names, and direction. Author - Fred Hofstetter.

5) FIRST THRU THIRD-ORDER INTERVALS:- produces frequency counts of intervals through the third order expressed by qualitative and quantitative names and by direction. Author - Fred Hofstetter.

6) HARMONIC ANALYSIS:- identifies tonic and mode of a tonal composition, and classifies each simultaneity by chord quality, inversion, root, and function. Nonharmonic tone identification is given for simultaneities which do not match specified patterns. This analysis is based on the intervallic content of simultaneities. Author - Ann Blombach.

7) HANSON ANALYSIS:- applies Howard Hanson's (1960) system of triad analysis to third-order melodic figures. This program produces a list of the classifications in order of their occurrence, and a codification according to each class. Author - Steven Holloway.

8) NOTE-VALUE PATTERNS AND CUES TO FORM
9) SCALE-DEGREE PATTERNS AND CUES TO FORM
10) SIMULTANEITY PATTERNS AND CUES TO FORM
11) CORRELATE CUES TO FORM

These programs provide tables of patterns found in musical works, and compute cue to form weights, a function of the endings of patterns. The simultaneity program is based on the Mason (1969) encoding algorithm. Author - Fred Hofstetter.

12) ROOT ANALYSIS:- combines programs #3 and #5 with a method of encoding chord roots in MUSICODE. Author - Millard Neal.

13) MAGIC SQUARE:- produces a magic square (Austin, 1966, 297) for twelve-tone rows specified by the user. Author - Fred Hofstetter.

14) SIMULTANEITY STRING ANALYSIS:- classifies simultaneities by the intervallic content among temporally ordered note-strings, and produces a table showing the number of occurrences in each class. Author - Richard Saalfeld.

15) CHI-SQUARE ANALYSIS:- performs chi-square analysis on data punched by analytical programs. The number of data sets and the number of categories are variable and self-defined by the program. Output shows observed, expected and chi-square values for each cell, the degrees of freedom in the matrix, and the summation chi-square. Author - Fred Hofstetter.

The usefulness of these programs can be seen from computer-assisted solutions to two musicological problems. The first problem is presented by bars one through eight of the first movement of Webern's Opus 28 string quartet. This movement is based on a twelve-tone row exposed by the first twelve notes of the piece. One would expect the next row to begin with the thirteenth note, but this is not the case. The next discernible row begins with the twenty-first note. The question is: does a structural basis exist for notes thirteen through twenty? Application of the ROW-TEASE program to the measures in question exposed the formal structure. The ROW-TEASE program found rows occurring from notes one through twelve, five through sixteen, and nine through twenty. This overlapping of twelve-tone rows explained the presence of notes thirteen through twenty.

The second problem concerns a comparative analysis of Dvorak's Quartet in E-flat and Borodin's Quartet in A. The question is: can we discriminate between Dvorak and Borodin on the basis of melodic intervals found in their principal themes? The answer to this problem involved two steps. First, the FIRST-ORDER INTERVALS program was applied to the principal themes of the two quartets. Then the CHI-SQUARE ANALYSIS program was applied to these results, revealing that the interval usages of the two composers are significantly different beyond the .1% level. The discriminators are augmented and diminished intervals, minor seconds, and minor thirds. Borodin is characterized by conjunct motion and frequency of augmented and diminished intervals. Dvorak uses more melodic skips and relatively few augmented and diminished intervals.

II. Statistical Research in Music Education

Dr. Henry L. Cady, graduate professor in music education at Ohio State, has conducted two computer-assisted studies in music education. The first was an analysis of the career preferences of music majors. A paired-comparison schedule was constructed in two parts. Part one was based on ten teaching careers, and part two on fifteen careers including the ten teaching careers reduced to five categories. This test was administered to 351 music majors. Their responses on sensitized sheets were converted to computer cards, and the computer ranked the careers by sex, instrument (including voice), age, academic year, major, and grade-point average. Rank order correlations were then performed to determine changes in career preference by academic year.

Dr. Cady's second study was a correlational investigation of 66 music student-teachers' career preferences, self-concept of ability to teach music (Wink, 1967), performance on the Minnesota Teacher Attitude Inventory, and academic achievement. The computer was used to find significant differences and correlations among pre, post, and gain scores. Roger Brown, Edward Asmus, and Shu-Ping-Chai have assisted Dr. Cady in this project.

Dr. Carl D. King's study of children's musical concepts required tests for significant differences between rural and urban children and regression for several variables - home musical environment, a pretest including nonwestern music, age, and grade level. Mr. John A. Pennington, currently pursuing a doctorate in music education, constructed a music peak experience scale, using the ideas of Maslow, which required item analyses at several stages. Responses were analyzed for differences between populations and regression for personal characteristics. Dr. Stephen H. Barnes' study of music teachers' roles required a variety of techniques, including differences between types of respondents, multiple range tests, and reliabilities.

Dr. Robert F. Wermuth's study of differences in musical ability between white and black children considered differences by age and grade, and regression for home musical environment, family and child interest, participation in music, and intelligence quotient. Dr. E. Richard Shoup studied supply, demand, mobility, and status characteristics of a stratified proportionate sample of Ohio music teachers (N=1003). Mr. Charles Temple, graduate music student (Ph. D. Cand.) in music education, has undertaken a computer-assisted study to determine whether excellence in band competition results in higher levels of music achievement and performance skills.

III. Synthetic Systems

Synthetic systems available at The Ohio State University include a computer system for voltage control of external devices (Hofstetter, 1972b), and a system whereby the computer performs the entire sound synthesis requiring only a tape recorder to receive the signal (Hofstetter, 1972c). Both systems utilize the PDP-9 computer system, and operate in a conversational environment. Two programs comprise the real-time system for voltage-control:

1) VFILE:- produces scores or schedules of sonic events as specified by the user. Variables are the values to be transmitted through the three channels of the D-A converter, and the amount of time each value is to be transmitted.

2) VOLTS:- reads scores produced by VFILE and converts them into voltages which control external devices, such as the Moog synthesizer.

The system for direct production of synthetic sound is capable of producing a wider variety of sounds than classical tape-laboratory equipment. Its major limitations are its requirement of large amounts of computer storage and the excessive amount of time required to produce complex sounds. Both of these limitations could be avoided by procurement of a larger and faster computer, as will be discussed in the final section of this paper. Four computer programs comprise the system:

1) SCHEMA:- produces a digital schematic diagram for the desired sound source (instrument). It consists of two sections: unit identification and patching. Units currently available consist of sine, square, triangular, sawtooth and pulse wave oscillators, formant generators, white (random) noise generators, envelope generators, amplifiers, and attenuators. Since all of these units are software, they can be used any number of times in any possible configuration.

2) SCORE:- produces schedules of sonic events which supply SCHEMA units with required variables at specified times.

3) COMP:- compiles SCHEMA and SCORE files and prepares the computer for the sound synthesis.

4) SYNTH:- automatically performs the sound synthesis as many times as the user desires.

Applications of synthetic systems to composition are widely known, and these systems have been likewise applied. Synthetic systems can also be used by scholars to study aural perception. Mr. David Butler, graduate teaching associate in music theory at Ohio State, has used the system for voltage control to study our perception of combination tones. By using the computer to produce sound stimuli, the researcher can be certain that only known variables change.

IV. Bibliographic Systems

Mr. David Butler is developing a general purpose bibliographic system which allows the researcher to obtain listings of and indexes to his bibliography by author, subject matter, date of publication, secondary sources, and language, in any of the standard bibliographic styles. The system includes provisions for underscoring and for printing both upper and lower-case letters.

V. Computer-Assisted Instruction in Music Theory

Programs for teaching freshman music theory concepts have been developed by Mr. Michael Arenson, graduate teaching associate in music theory at Ohio State, under the supervision of Dr. Burdette Green, head of Freshman Theory at Ohio State. These materials, written in Coursewriter III, supplement classroom instruction and are available to students on a voluntary basis. Listed by course, they include:

Music 221 (first quarter theory):

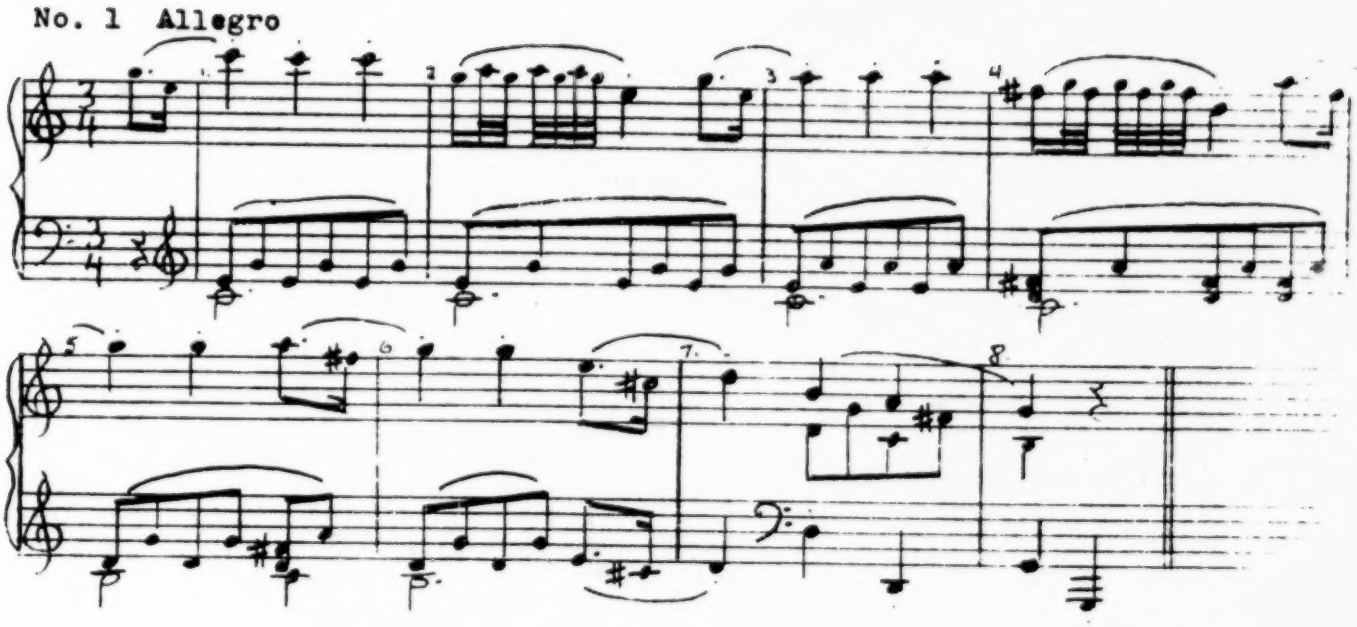
1) Construction and Spelling of Intervals.
2) Triad Construction and Placing Chords in Keys.
3) Diagnostic, instructional and drill-practice program concerning the grand staff, ledger lines, and octave-transposition signs.

Music 222 (second quarter theory):

1) Spelling and Manipulation of Seventh Chords.

Music 223 (third quarter theory):

1) Altered Chords.
2) Problems concerning altered chords and modulation.

To illustrate how a freshman might use one of these programs, let us examine one of the segments of the program "Problems concerning altered chords and modulation". Given the following score-fragment, the student is asked: "This excerpt is in how many keys?" If he says "Two", he is told that he has answered correctly. If the student answers incorrectly, the program guides him to the correct answer. For example, if he says "One", he is told to look at the first and last measures and answer again. If he says "Three", he is told that "measures 6 and 7 do have what appears to be a vii^{o} going to I in the key of D major, but this progression does not constitute a change of key, because D is not confirmed by a cadence. Try again". When the student answers correctly, he is asked to find the pivot chord.

VI. Automated Music-Printing

Mr. Gerald Hoekstra, university fellow in music history, and Mr. Michael Hogan, undergraduate computer-science major, are developing a program which will print music in score. The input language is MUSICODE, and output is received on a CalComp plotter. Mr. Hoekstra plans to use this program in transcribing and editing eighty chansons, which now exist in part-books written in sixteenth-century black notation. The program will correctly align the several voices and will insert bar-lines between the staves in the proper places. A further convenience of this system is that the MUSICODE used in editing the chansons can also be used to obtain analyses from the programs discussed in section I.

VII. The Future

Computer technology, still in its infancy, has provided us with high-speed digital secretaries which can read, write, draw, hear, speak, and even see. The musicologist is limited only by his imagination. Two computer systems being developed at Ohio State bear great potential for the future. One, combining the analytic programs discussed in Section I, will make possible an exhaustive study of musical style, for which Jan LaRue (1970) has provided a conceptual frame in his book on style analysis. The other, employing computers which can both accept and produce sound patterns, can be used to determine the characteristics and limits of our perceptual capabilities. These applications of computers to music will greatly contribute to musical knowledge in the future.

Bibliography

Austin, W. W. 1966. Music in the 20th century: From Debussy through Stravinsky. New York: W. W. Norton & Company, Inc.

Brook, B. S. & M. Gould. 1964. Notating music with ordinary typewriter characters (A Plaine and Easie Code System for Musicke). Fontes Artis Musicae, 11, 142-155.

Hanson, H. 1960. Harmonic materials of modern music; Resources of the tempered scale. New York: Appleton-Century-Crofts.

Hiller, L. A. & C. Bean. 1966. Information theory analysis of four sonata expositions. Journal of Music Theory, 10, 96-137.

Hofstetter, F. T. 1972a. A computer system for musical description. Journal of the Graduate Music Students at the Ohio State University, #3, 4-42.

Hofstetter, F. T. 1972b. A computer system for voltage control. Unpublished paper, Ohio State University.

Hofstetter, F. T. 1972c. COSYSOSYSOSU: A computer system for sound synthesis at the Ohio State University. Unpublished paper, Ohio State University.

LaRue, J. 1970. Guidelines for style analysis. New York: W. W. Norton & Company, Inc.

Mason, R. M. 1969a. An encoding algorithm and tables for the digital analysis of harmony: I. Journal of Research in Music Education, 17, 286-300.

Mason, R. M. 1969b. An encoding algorithm and tables for the digital analysis of harmony: II. Journal of Research in Music Education, 17, 369-387.

Wink, R. L. 1967. Relationship of self-concept and selected personality variables to achievement in music student teaching. Unpublished doctoral dissertation, The Ohio State University.

Acknowledgments

Computer applications to music would not exist at Ohio State without the consultation and encouragement of many administrators, professors and colleagues. The Instruction and Research Computer Center (IRCC) has provided the most generous use of its facilities, including the IBM 370/165 computer system with time-sharing option and the PDP-9 computer system with analogue converters. Mr. Thomas Whitney, a distinguished member of the IRCC, has been especially helpful. His dedication to students, expertise in programming, and insight into computing in the humanities are well-known and cherished throughout the university.

Dr. William Poland, professor of music theory, directs much of the research discussed in this paper. Aware of the significance of these applications in their infancy, he has encouraged students to pursue them by instituting Ohio State's first course in computer applications to music. His comprehensive knowledge of theories of music, awareness of the nature and capabilities of computers, and ability to solve problems at the conceptual level have greatly contributed to computing in music.

Dr. Lee Rigsby, Dean of the College of the Arts, has given these projects needed support, as have Dr. Harold Luce, Director of the School of Music, Dr. Marshall Barnes, chairman of the music theory department, Dr. Jay Huff, professor of composition, Dr. Henry L. Cady, professor of music education, and Dr. Keith Mixter, professor of music history. Professors Breeding, Warren, Olson, and Sullivan of the Electrical Engineering Department have assisted in developing the synthetic systems, and have most graciously encouraged our use of their facilities.